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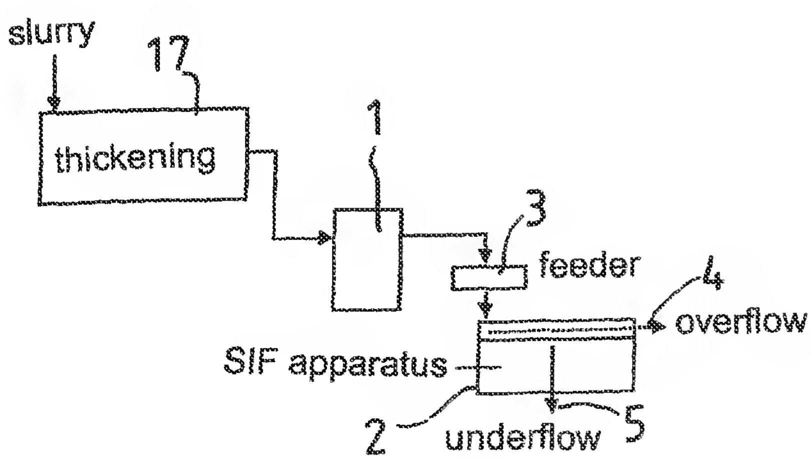
(54) **Title:** METHOD AND APPARATUS FOR SEPARATION IN FROTH AND USE OF A HELICAL ROTOR MIXER



(57) **Abstract:** In a froth flotation method and apparatus, a thick slurry is formed from a coarse-grained material and flotation chemicals. The slurry is prepared substantially without producing sludge in the slurry. In a flotation separator (2), a liquid phase is provided and a froth phase is arranged on the surface of the liquid phase. The slurry is fed into the froth phase, with the result that hydrophobic particles are caught in the froth, to be removed as a froth overflow, while hydrophilic particles sink through the froth into the liquid phase below it, to be removed as an underflow. In the preparator (1), the slurry is brought into a flowing motion with an axial vertically circulating flow pattern. The preparator (1) used is a helical rotor mixer.

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METHOD AND APPARATUS FOR SEPARATION IN FROTH AND USE OF A HELICAL ROTOR MIXER

FIELD OF THE INVENTION

The present invention relates to a method as defined in the preamble of claim 1. Moreover, the invention relates to an apparatus as defined in the preamble of claim 9. In addition, the invention relates to use of a helical rotor mixer as defined in claim 19.

BACKGROUND OF THE INVENTION

The invention relates to a flotation separation method and system known by the English designation Separation In Froth (SIF), designed for concentration of coarse minerals and for typical separation functions in recirculation technology. The SIF method and a preferable SIF froth flotation apparatus are described e.g. in specification WO 00/51744.

From literature it is known that the practice of conveying the slurry directly to froth was first introduced be Malinovsky, V.A. (1961) "Selective recovery of the hydrophobic and hydrophobized particles and some surface active agents by separation in froth". DAN SSSR 141,420-423. Furthermore, specifications US 3,434,596, US 4,274,949, US 4,469,591 and US 3,815,739 describe SIF devices.

The Separation In Froth (SIF) method is based on separation of materials in froth phase. An essential feature in the method is that ground feed material treated with chemicals is passed in a SIF flotation apparatus directly into froth. Thus, hydrophobic particles are caught in the froth and drift with it out of the flotation apparatus, whereas hydrophilic particles pass through the froth to the slurry layer

below it. In this way, an overflow to be removed with the froth phase and an underflow from the solution below are obtained. Separation thus occurs completely in the froth phase, where the dwell time is generally of the order of only 10 s.

The SIF method differs substantially from conventional flotation methods, wherein the contact between particles and bubbles is generated in the slurry and the ascension of particles together with air bubbles to the froth layer is a critical stage in respect of grain size. By the SIF method, it is possible to separate particles considerably coarser than the conventional flotation fineness, depending on the surface properties and the particle form and density of the material. Depending on the mineral, the maximum grain size in concentration is about 3 mm. In mineral concentration, the SIF method is advantageously applicable for treatment of the coarse fraction in the classification (screen, cyclone) in grinding circuits and in general in cases where the material is pure ground already in a coarse grain size.

The SIF method has the advantage that the processes can be substantially simplified, thereby achieving savings in grinding energy because a large grain size is acceptable and in chemical consumption because the method uses smaller amounts of flotation chemicals than conventional processes. Furthermore, due to the short dwell time in the SIF apparatus, the process is fast.

In the SIF method, it is preferable to use a high slurry density, which is generally of the order of 50-70%. Therefore, the slurry is generally prethickened e.g. by means of a spiral classifier. In some cases the slurry density is sufficiently high by nature, requiring no pre-thickening.

The problems in the prior-art SIF method are related to the preparation of a thick slurry with flo-

tation chemicals. The purpose of preparation is to bring the chemicals to the surface of the minerals. Previously known is the use of a drum-type preparator in the SIF process. The use of a drum-type preparator has been resorted to because the mixing properties of conventional preparators are generally not applicable for use in the case of the aforesaid high slurry density. This is because, due to the high local mixing energy, they tend to develop sludge, which has many adverse effects on the operation of the SIF process. For this reason, the only suitable method so far has been to perform the preparation using a drum-type mixer, in which the formation of sludge is insignificant due to a low speed or rotation.

The drum of a rotary drum mixer is usually a cylindrical container arranged to be rotated about its substantially horizontal center axis. The interior wall of the drum is provided with fixed mixing vanes to achieve a better mixing effect. The rotary drum mixer is a continuous-action mixer. The slurry to be mixed is fed into the drum via one end and delivered from the other end. The slurry flow pattern in the preparator is a so-called plug flow pattern.

A disadvantage is that the rotary drum mixer is a device that requires a large floor area. This is a problem especially in the production areas of an existing flotation plant where the processes are renewed to use the SIF method but the buildings are not to be expanded for this purpose. In addition, the drum of a drum-type preparator can be filled only partially because usually about two thirds of its inside space has to be left empty. Thus, the about 30-% degree of filling of the drum is poor. A further problem is that the preparation time is relatively long.

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OBJECT OF THE INVENTION

The object of the present invention is to overcome the above-mentioned drawbacks.

A specific object of the invention is to disclose a froth flotation method and an apparatus wherein the preparator takes up as little space as possible.

A further object of the invention is to disclose a froth flotation method and an apparatus wherein the slurry preparation time is as short as possible.

BRIEF DESCRIPTION OF THE INVENTION

The method of the invention for separation in froth is characterized by what is disclosed in claim 1. Further, the apparatus of the invention for separation in froth is characterized by what is disclosed in claim 9. The use of a helical rotor mixer is characterized by what is disclosed in claim 19.

According to the invention, in the preparation stage of the method, the slurry is brought into a flowing motion with an axial vertically circulating flow pattern.

According to the invention, the preparator in the apparatus is a helical rotor mixer.

The invention has the advantage that the preparator producing the aforesaid flow pattern, in practice the helical rotor mixer, being mounted in an upright position, only takes up little space. Existing flotation plants can be adapted for the SIF process without building additional space. The degree of filling of the preparator used is high because the container of the helical rotor mixer is preferably filled completely with slurry to be prepared. The dwell time of slurry in the preparator is short, allowing the

preparation stage of the SIF process to be substantially accelerated.

In an embodiment of the method, the axial vertically circulating flow is produced by a helical rotor mixer having a double helix rotor provided with two spiral tubes of round cross-section twisted around a vertical center axis of rotation at a constant radial distance.

In an embodiment of the method, the helix angle of the spiral tubes is selected to be 15° - 50°.

In an embodiment of the method, the particle size of the coarse-grained material is selected to be at most about 3 mm.

In an embodiment of the method, the slurry is formed to a slurry density of 50-70%.

In an embodiment of the method, the slurry is thickened before preparation.

In an embodiment of the method, the mixing efficiency is adjusted by varying the speed of rotation of the helical rotor, thereby changing the flow velocity of the circulating flow.

In an embodiment of the method, the speed of rotation of the helical rotor is so adjusted that the flow velocity is at most 2.0 m/s, preferably at most 1.0 m/s.

In an embodiment of the apparatus, the preparator comprises a container whose interior space is defined laterally by a cylindrical vertical side wall and below by a planar bottom. A double helix rotor is arranged centrically in the interior space of the container. A power means is provided to rotate the double helix rotor at a predetermined speed of rotation. Mounted on the side wall inside the container are a number of elongated vertical flow inhibitors protruding from the side wall towards the center axis of the container.

In an embodiment of the apparatus, the double helix rotor comprises a vertical shaft, which is connected to the power means. Two identical spiral tubes of round cross-section are secured to the shaft by means of supporting arms opposite to each other mutually symmetrically at a radial distance from the shaft.

In an embodiment of the apparatus, the helix angle of the spiral tubes is 15° - 50°.

In an embodiment of the apparatus, the rotor diameter equals 0.5 - 0.8, preferably 0.65 - 0.7 times the inner diameter of the container.

In an embodiment of the apparatus, the diameter of the double helix rotor equals 0.5 - 0.8, preferably 0.65 - 0.7 times the inner diameter of the container.

In an embodiment of the apparatus, the spiral tubes twist around the vertical shaft through 1/2, 5/8, 2/3, 3/4, 7/8 or 1 turn.

In an embodiment of the apparatus, the diameter of the spiral tubes equals 0.04 - 0.07 times the rotor diameter.

In an embodiment of the apparatus, the flow inhibitor has a width equaling 1/12 - 1/9 times the inner diameter of the container.

In an embodiment of the apparatus, the flow inhibitor and the container wall are separated by a circumferential clearance of a width equal to 0.01 - 0.04 times the inner diameter of the container.

In an embodiment of the apparatus, the number of flow inhibitors is 3 - 12 pcs, preferably 6 - 8 pcs.

LIST OF FIGURES

In the following, the invention will be described in detail with reference to embodiment examples and the attached drawing, wherein

Fig. 1 presents a diagram representing the principle of a prior-art SIF process,

Fig. 2 represents a SIF process according to an embodiment of the SIF process of the invention, and

Fig. 3 presents a vertical section of the preparator used in the SIF process in Fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 represents a prior-art SIF process wherein a coarse-grained material having a particle size of the order of about 0.1 - 3 mm is first thickened by means of a thickening device 17, e.g. a spiral classifier, to a slurry density of 50 - 70%. The thickened slurry is then fed into a preparator 1, where the slurry is prepared substantially without forming sludge in it, in other words, without causing the particles to be ground into finer fractions. As stated above, the preparator 1 used in prior art is a rotary-drum preparator with a preparator drum rotating about a horizontal axis. From the preparator drum the slurry is passed via a feeder 3 into a flotation separator 2, which contains a froth phase and a liquid phase under the froth phase. The slurry is fed into the flotation separator 2 so that it comes directly into the froth phase, with the result that hydrophobic particles are caught in the froth and can be removed from the device as a froth overflow by first removal means 4. Hydrophilic particles sink through the froth into the liquid phase under it and can be removed from the device by second removal means 5.

The SIF process according to the invention presented in Fig. 2 is similar to the process illustrated in Fig. 1, reference being made to the description thereof, but differs from it only in respect of the preparator 1. Here, preparation is performed by means of a compact preparator using a helical rotor, wherein the helical rotor sets the slurry in vertical

axial flow. A feature characteristic of this mixing arrangement is that the helical rotor has a relatively large size in relation to the preparator. The rotor itself covers 25 - 55% of the effective volume of the whole preparator and preferably 35 - 45% of this volume. 'Effective volume' refers to the volume remaining within the flow inhibitors. This size is so large that, rotating in a lifting direction, the mixer produces a circulating flow moving upwards at the circumference of the preparator and downwards in the central part. The circulating flow runs heavily directly towards the bottom and, assisted by the lower supports of the helical mixer, turns towards the circumference while simultaneously diverging in every direction, to turn upwards again here near the bottom. Similarly, having reached a level near the surface, the circulating flow turns towards the center and here from near the surface further downwards. According to our invention, by using a large lifting-action mixer having a structure as described below and a preparator adapted to the size and use of the mixer, very uniform mixing extending throughout the entire slurry volume of the preparator is achieved.

The mixing intensity is adjusted by varying the helical rotor mixer's speed of rotation, which has a direct effect on the flow rate of the circulating flow and therefore on the turbulence appearing in it. The intensity of uniform mixing can be adjusted within wide limits, which is due to the size and structure of the mixer, among other things. There is no actual low limit to the flow rate, while the high limit lies between 1.5 - 2.0 m/s. However, the remixing time is quite short even at considerably lower flow rates. In most cases of preparation, it is appropriate to reduce the circulating flow to a rate below 1.0 m/s, down to a rate between 0.2 m/s and 0.6 m/s, which has been found to produce a sufficient mixing effect. The mix-

ing is improved by the fact that there appear in the circulating flow cross flows produced by the supporting arms extending from the shaft of the mixer to the helix tubes.

In SIF preparation it is important to avoid sludge formation, i.e. grinding of solid matter as a result of locally intensive mixing. As explained later on, the helical rotor according to our invention which is used as a mixer has expressly a structure that minimizes the grinding effect. The rotor is constructed from round tubes and shaped as a symmetrical double helix, by the selection of whose helix angle it is possible to influence the mixing angle meeting the slurry. In addition to what was stated above, especially the relatively large size of the helical rotor greatly reduces the grinding of the slurry expressly because no locally intensive mixing occurs. Mixing continues to be uniform and controlled even when the size of the preparator is increased, which would not be possible if a smaller mixer rotating in a limited preparator space were used. This can be established by way of example by observing how the circumferential speed of the helical mixer increases as the preparator size increases when the diameter of the helical mixer equals 70 % of the diameter of the preparator. When the circumferential speed lies between 2.2 m/s and 4.0 m/s in a 10-m^3 preparator and between 2.5 m/s and 4.5 m/s in a 50-m^3 preparator, a range of 3.0 m/s to 5.2 m/s is sufficient in a large 300-m^3 preparator. Let it be stated that in the aforesaid preparator volumes e.g. circumferential speeds of 3.0 m/s, 3.5 m/s and 4.0 m/s give the same average mixing intensity when the preparator volumes are taken into account in their entirety.

In preparation it is important that the contents of the preparator be thoroughly mixed in a uniform manner to ensure that no part of the supply is

passed through the preparator as an incompletely mixed cross flow. In such a case the preparation is insufficient, and consequently the preparation chemicals have not been applied correctly to the intended mineral surfaces. According to our invention, the prevention of the occurrence of this situation has been ensured by introducing controlled surface feed for the slurry to be prepared and the preparation chemicals. The most preferable method is to feed the slurry and chemicals from above to the surface of the preparator, the slurry to one side and the chemicals to the other side, the feed points being disposed symmetrically or nearly symmetrically relative to each other. The best feed points are located in the vicinity of the vertical flow inhibitors, near the inner edge of these and preferably obliquely relative to the radial direction of the preparator against the direction of rotation of the helical mixer. At these points, the surface flow is particularly intensive and is directed in a spiral fashion towards the center. Using this feed arrangement, the supplies meet at the center of the preparator and are drawn down by suction from the surface, being simultaneously mixed together in the flow towards the bottom. In fact, this feed method improves the performance characteristics of the preparator from the performance efficiency of a conventional "backmixed" reactor because no part of the feed can cross directly or nearly directly out of the preparator. Let it be further stated that, already for technical reasons of mixing, the number of vertical flow inhibitors is mainly 6 - 8 pcs, which allows several chemicals to be fed, if necessary, in the vicinity of adjacent flow inhibitors.

A fully developed surface flow of correct type is achieved when the helical rotor does not extend to the surface. It is desirable that the upper ends of the rotor should extend to a surface distance

of 30 - 90 cm from the cover of the container, depending on the size of the preparator. Let it be stated that the bottom clearance of the helical rotor is of the order as the surface distance, yet often smaller, but not less than half the said surface distance. Fig. 3 gives a more detailed illustration of the structure of the helical rotor mixer 1.

Fig. 3 shows the preparator 1 used in the SIF process in Fig. 2. The preparator 1 comprises a container 6, whose interior space 7 is defined laterally by a cylindrical vertical side wall 8 and below by a bottom 9. A double helix rotor 10 is disposed centrically in the interior space 7, to be rotated by a power means 11. From the side wall 8 of the container 6 there extend towards the interior space 7 a number of elongated vertical flow inhibitors 12.

The double helix rotor 10 comprises a vertical shaft 13, which is connected to the power means 11. In addition, the rotor 10 comprises two identical spiral tubes 14, 15, i.e. the aforesaid helix tubes, which are of round cross-section and fastened to the vertical shaft 13 by means of supporting arms 16 opposite to each other symmetrically relative to each other at a radial distance from the shaft. The diameter of the double helix rotor 10 is relatively large in relation to the diameter of the preparator, generally 0.5 - 0.8 times the preparator diameter and preferably 0.65 - 0.70 times the preparator diameter.

In the example case in Fig. 3, both of the mutually symmetrical helix tubes 14, 15 ascend through half a turn around the shaft 13, this helix angle being between 30° - 40°, which is advantageous to use when solid matter is to be flotated. However, the height of the preparator can be increased in relation to its diameter, the height of the helical rotor being simultaneously increased according to the recommended surface distance mentioned above. It is preferable to

keep the helix angle within the above-mentioned range and correspondingly to continue the twist of the two helix tubes about their axis. Depending on the shape of the preparator, the helix tubes 14, 15 twist around the shaft 13 e.g. through 5/8, 2/3, 3/4, 7/8 of a turn or one complete turn, the height of the preparator being simultaneously increased to nearly double relative to its diameter in relation to the example presented in Fig. 3. The height of the preparator can also be reduced in a corresponding manner by introducing helical rotors with helix tubes twisted e.g. through 3/8 of a turn about their axis.

When the risk of sludge formation is small, it is possible to use intensive mixing, in which case an alternative solution will be to use a rotor with helix tubes at a steeper helix angle, e.g. between 40° - 50°. For example, if helix tubes twisted through 3/8 of a turn about their axis are used, preparation will be performed in this category. In this case, more efficient preparation will be achieved by using a large number of vertical inhibitor vanes, e.g. 8 pcs.

The diameter d_h of the helix tubes 14, 15 of the rotor is preferably 0.04 - 0.07 times the diameter of the rotor itself. The same applies to the lowest helix tube supporting arms, which follow the bottom profile of the preparator at a constant distance. The other supporting arms, the spacing of which has been determined on the basis of stiffness considerations, are disposed at a rising angle towards the shaft, preferably at an angle of 60° relative to the shaft. The uppermost supporting arms are correspondingly inclined at a falling angle relative to the shaft, preferably likewise at an angle of 60°, to ensure that the arms do not extend to a level higher than the upper ends of the helix tubes. In a half-turn helical mixer, the number of supporting arms is generally 3-5 pcs per helix tube. A usable angular spacing as seen from be-

low is e.g. 0°, 30°, 70°, 110° and 150°, in which case the number of supports is five for each helix tube.

The width of the vertical flow inhibitors 12 is 1/12 - 1/9 of the diameter of the preparator, preferably of the order of 1/10 of said diameter. The vertical flow inhibitors are mounted near the inner surface of the cylindrical side wall 8 of the container 6 so that a circumferential clearance having a width s of 0.01 - 0.04 times the preparator diameter D, preferably 0.02 times the preparator diameter. The number of flow inhibitors 12 is 3 - 12 pcs, preferably 6 - 8 pcs.

In the embodiment presented in Fig. 3, the spiral tubes 14, 15 comprise a first spiral tube 14, which has an upper end 18 and a lower end 19, and a second spiral tube 15, which has an upper end 20 and a lower end 21. The upper end 18 of the first spiral tube 14 and the upper end 20 of the second spiral tube 15 are at the same first horizontal plane T_1 on opposite sides of the vertical shaft 13 of the rotor. The lower end 19 of the first spiral tube 14 and the lower end 21 of the second spiral tube 15 are at the same second horizontal plane T_2 on opposite sides of the vertical shaft 13 of the rotor. The upper end 18 of the first spiral tube 14 and the lower end 21 of the second spiral tube 15 are at the same first vertical line L_1. The lower end 19 of the first spiral tube 14 and the upper end 20 of the second spiral tube 15 are at the same second vertical line L_2, which is on the opposite side of the vertical shaft of the rotor in relation to the first vertical line L_1.

EXAMPLE EXPERIMENT

<u>1. Rotary drum mixer as preparator in SIF process</u>

The feed material in the process was waste from a phosphate concentrating plant, from which the coarse fraction had been separated by classifying in a cyclone. The solid matter content of the slurry was about 60%. The thick slurry was conveyed to a feeder and through it further into a SIF apparatus. The feed rate in the process was 29.5 t/m^{2}h, expressed in relation to the active froth area of the SIF cell. The dwell time in the preparator drum was 8 min.

The results of the process were as follows:

	Mass %	P_2O_5 content (%)
Feed	100.0	1.02
Concentrate	13.5	5.95
Waste	86.5	0.25

<u>2. Helical rotor mixer as preparator in SIF process</u>

The feed material in the process was waste from a phosphate concentrating plant, from which the coarse fraction had been separated by classifying in a cyclone. The solid matter content was 65%. The thick slurry was conveyed to a feeder and through it further into a SIF apparatus. The solid matter feed rate was 38.7 t/m^{2}h. The effective dwell time was 8 min.

The results were as follows:

	Mass %	P_2O_5 content (%)
Feed	100.0	0.56
Concentrate	13.0	2.88
Waste	87.0	0.21

Example experiments 1 and 2 show that, in the SIF process provided with a helical rotor mixer, the

P_2O_5 content was somewhat lower than in the process provided with a rotary drum mixer (0,21% vs. 0,25%). However, the P_2O_5 content of the product going into final waste is the most important value in respect of the total process, so even a small change in the P_2O_5 content of the waste is significant. In addition, it is to be noted that in the example with a helical rotor mixer the P_2O_5 content of the feed is only about half the P_2O_5 content of the feed material fed into the rotary drum mixer.

The dwell time in the helical rotor preparator was 4.5 min vs. 8 min in the rotary drum preparator. The result shows that the mixing efficiency of the helical rotor preparator is better than or at least as good as in the rotary drum preparator.

The invention is not limited to the embodiment examples described above; instead, many variations are possible within the scope of the inventive concept defined in the claims.

CLAIMS

1. Froth flotation method for concentrating minerals from a coarse-grained material, in which method

- a thick slurry is formed from the coarse-grained material and flotation chemicals,

- the slurry is prepared substantially without producing sludge,

- a liquid phase is provided and a froth phase is arranged on the surface of the liquid phase, and

- the slurry is fed into the froth phase, with the result that hydrophobic particles are caught in the froth, to be removed as a froth overflow, while hydrophilic particles sink through the froth into the liquid phase below it, to be removed as an underflow, characterized in that in the preparation stage of the method, the slurry is brought into a flowing motion with an axial vertically circulating flow pattern.

2. Method according to claim 1, characterized in that the axial vertically circulating flow is produced by a helical rotor mixer having a double helix rotor provided with two spiral tubes of round cross-section twisted around a vertical center axis of rotation at a constant radial distance.

3. Method according to claim 3, characterized in that the helix angle of the spiral tubes is selected to be 15° - 50°.

4. Method according to any one of claims 1 - 3, characterized in that the particle size of the coarse-grained material is selected to be at most about 3 mm.

5. Method according to any one of claims 1 - 4, characterized in that the slurry is formed to a slurry density of 50-70%.

6. Method according to any one of claims 1 - 5, c h a r a c t e r i z e d in that the slurry is thickened before preparation.

7. Method according to any one of claims 1 - 5, c h a r a c t e r i z e d in that the mixing efficiency is adjusted by varying the speed of rotation of the helical rotor, thereby changing the flow velocity of the circulating flow.

8. Method according to claim 7, c h a r a c t e r i z e d in that the speed of rotation of the helical rotor is so adjusted that the flow velocity is at most 2.0 m/s, preferably at most 1.0 m/s.

9. Froth flotation apparatus for enrichment of minerals from a coarse-grained material, said apparatus comprising a preparator (1) for preparation of a slurry consisting of the coarse-grained material and flotation chemicals; a flotation separator (2) containing a froth phase and a liquid phase; feeding means (3) for feeding the slurry into the froth phase; first removal means (4) for removing the froth overflow and second removal means (5) for removing the slurry as an underflow from the liquid phase, c h a r a c t e r i z e d in that the preparator (1) is a helical rotor mixer.

10. Apparatus according to claim 9, c h a r a c t e r i z e d in that the preparator comprises

- a container (6) whose interior space (7) is defined laterally by a cylindrical vertical side wall (8) and below by a bottom (9),
- a double helix rotor (10) arranged centrically in the interior space (7),
- a power means (11) for rotating the double helix rotor (10), and
- a number of elongated vertical flow inhibitors (12) protruding from the side wall (8) towards the center axis of the container.

11. Apparatus according to claim 10, c h a r a c t e r i z e d in that the double helix rotor comprises

- a vertical shaft (13) connected to the power means (11),

- two identical spiral tubes (14, 15) of round cross-section and secured to the vertical shaft (13) by means of supporting arms (16) opposite to each other mutually symmetrically at a radial distance from the shaft.

12. Apparatus according to claim 11, c h a r a c t e r i z e d in that the helix angle of the spiral tubes (14, 15) is 15° - 50°.

13. Apparatus according to any one of claims 10 - 12, c h a r a c t e r i z e d in that the diameter of the double helix rotor (10) equals 0.5 - 0.8, preferably 0.65 - 0.7 times the inner diameter (D) of the container (6).

14. Apparatus according to any one of claims 11 - 13, c h a r a c t e r i z e d in that the spiral tubes (14, 15) twist around the vertical shaft (13) through 1/2, 5/8, 2/3, 3/4, 7/8 of a turn or 1 turn.

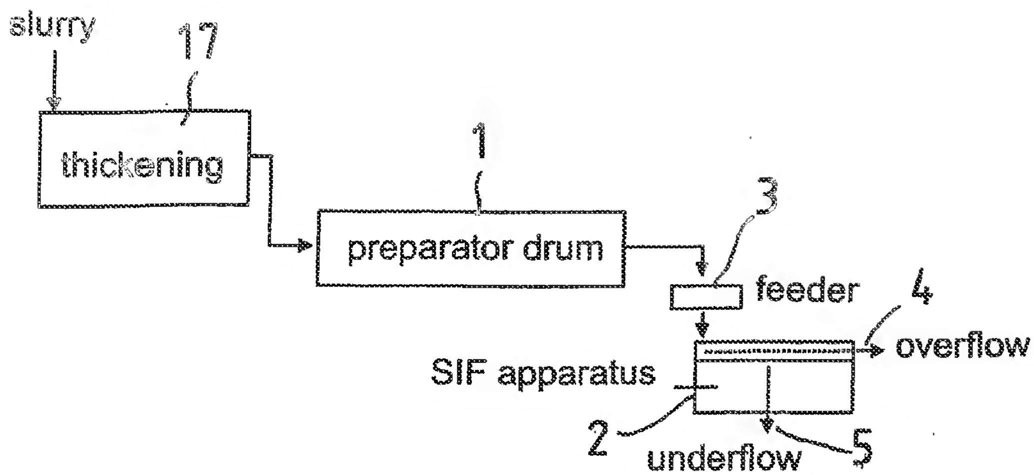
15. Apparatus according to any one of claims 11 - 14, c h a r a c t e r i z e d in that the diameter (d_h) of the spiral tubes equals 0.04 - 0.07 times the diameter (d) of the rotor (10).

16. Apparatus according to any one of claims 11 - 15, c h a r a c t e r i z e d in that the flow inhibitor (12) has a width equaling 1/12 - 1/9 times the inner diameter (D) of the container (6).

17. Apparatus according to any one of claims 11 - 16, c h a r a c t e r i z e d in that the flow inhibitor (12) and the wall (8) of the container (6) are separated by a circumferential clearance having a width (s) equal to 0.01 - 0.04 times the inner diameter (D) of the container (6).

18. Apparatus according to any one of claims 11 - 17, c h a r a c t e r i z e d in that the number of flow inhibitors (12) is 3 - 12 pcs, preferably 6 - 8 pcs.

19. Use of a helical rotor mixer as a preparator in a SIF process.



PRIOR ART

Fig 1

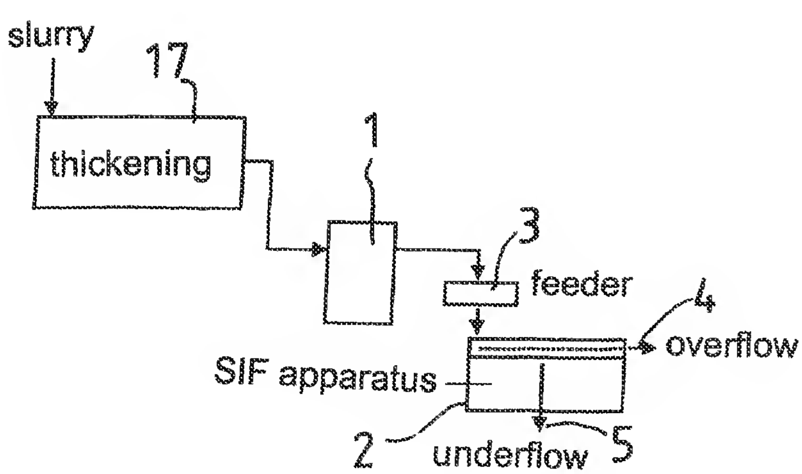
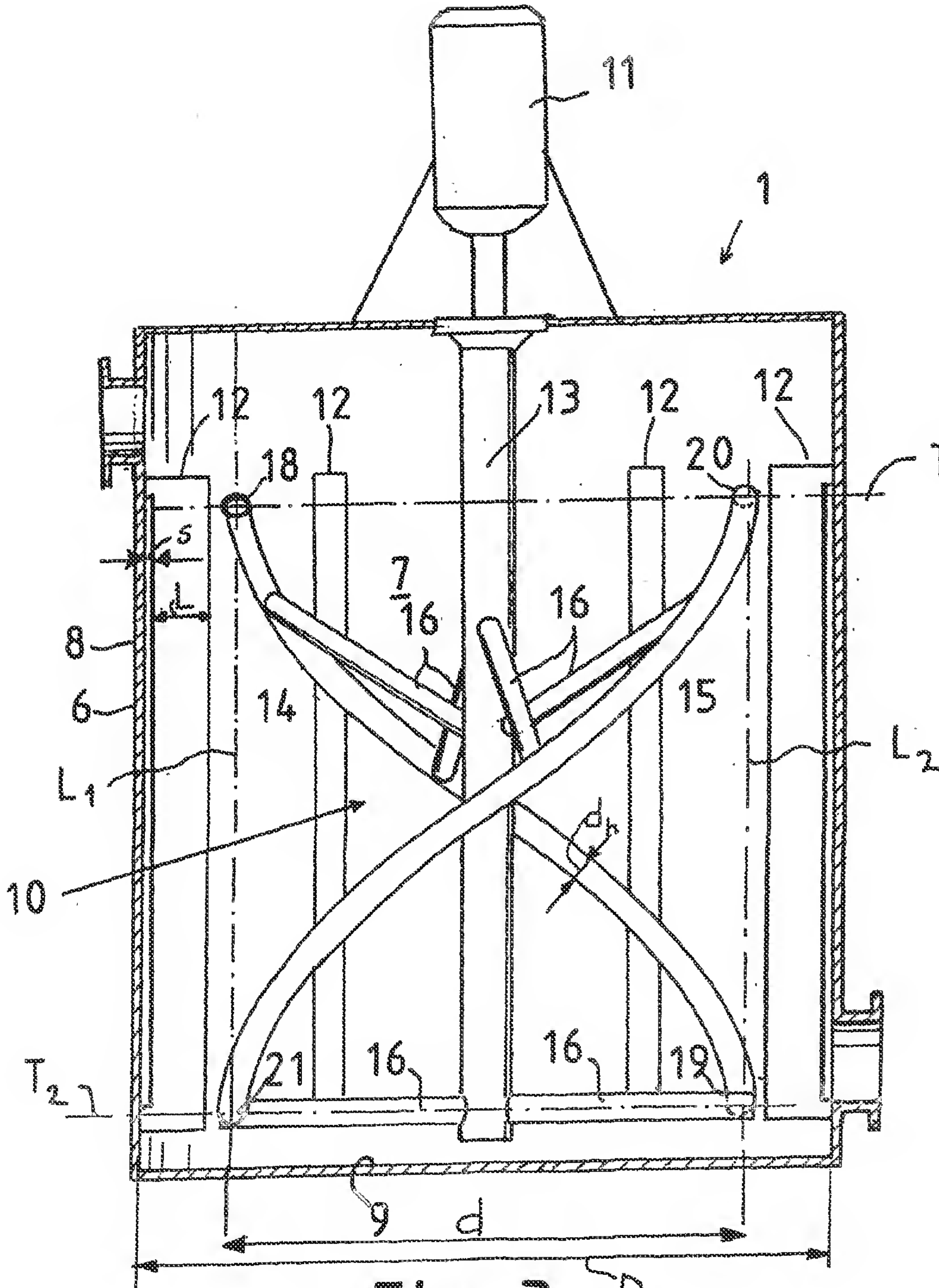


Fig 2



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T1
s
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L
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L1
L2
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dh
T2
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D

Fig 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 2004/000236

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B03D 1/02, B03B 1/04, B01F 7/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B01F, B03B, B03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0051744 A1 (EKO-TEKNIKKA-TURKU OY), 8 Sept 2000 (08.09.2000), abstract --	1-19
A	US 3254762 A (RANDEL E. SMITH ET AL), 7 June 1966 (07.06.1966), column 1, line 27 - line 51; column 2, line 20 - line 37, figure 1 --	1-19
A	US 933768 A (DAVID WESTON), 14 August 1963 (14.08.1963), page 1, line 83 - page 2, line 13, figure 1 --	1-19

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2004	28 -07- 2004
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer JENS WALTIN/BS Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5182087 A (LILJA ET AL), 26 January 1993 (26.01.1993), column 2, line 6 - line 33; column 4, line 55 - column 5, line 30, figure 1 --	1-19
A	WO 03000379 A1 (OUTOKUMPU OYJ), 3 January 2003 (03.01.2003), figure 1, abstract --	1-19

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US	933768	A	14/08/1963	NONE			
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				FI	84787	B,C	15/10/1991
				FI	901693	A	05/10/1991
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				EP	1399234	A	24/03/2004
				FI	20011352	A	26/12/2002